REMARKS

In view of the above amendments and the following remarks, reconsideration of the rejections contained in the Office Action of April 14, 2006 is respectfully requested.

By this Amendment, claims 1-14 have been cancelled and new claims 15-24 have been added and are currently pending in the application. No new matter has been added by these amendments.

In order to make editorial improvements, the entire specification and abstract have been reviewed and revised. Due to the number of revisions, the amendments to the specification and abstract have been incorporated into the attached substitute specification and abstract. For the Examiner's benefit, a marked-up copy of the specification and abstract indicating the changes made thereto is also enclosed. No new matter has been added by the revisions. Entry of the substitute specification is thus respectfully requested.

On page 2 of the Office Action, the Examiner objected to claims 9-14 under 37 C.F.R. § 1.75(c) as being in improper form. Specifically, the Examiner asserted that claims 9-14 were improper multiple dependent claims because they did not refer back in the alternative to the claims from which they depend. As indicated above, claims 1-14 have been cancelled and replaced with new claims 15-24, which include multiple dependent claims 20-24. Claims 20-24 properly refer back in the alternative to the claims from which they depend, and it is therefore respectfully submitted that the objections under 37 C.F.R. § 1.75(c) are not applicable to the new claims.

On page 2 of the Office Action, the Examiner rejected claim 1 under 35 U.S.C. § 112, second paragraph, as being indefinite. In particular, the Examiner asserted that the limitation "the variable gas flow channel" lacked antecedent basis. However, as indicated above, claims 1-14 have been cancelled and replaced with new claims 15-24, and the new claims have been drafted so as to fully comply with all the requirements of 35 U.S.C. § 112. Therefore, it is respectfully submitted that the Examiner's formal rejections under § 112 are not applicable to the new claims.

On pages 2-3 of the Office Action, the Examiner rejected claims 1-8 under 35 U.S.C. § 102(e) as being anticipated by McElroy (US 6,251,534). However, as indicated above, claims 1-14 have been cancelled and replaced with claims 15-24. For the reasons discussed below, it is

respectfully submitted that the new claims are clearly patentable over the prior art of record.

The discussion of the invention provided below makes reference to the specification and figures of the present application. However, these references are made only for the Examiner's benefit, and are not intended to otherwise limit the claims.

The present invention is directed to a fuel cell system which, as shown in Figs. 1-4, includes cells having an anode gas flow plate 5 and a cathode gas flow plate (represented in Figs. 1 and 3 by the cathode gas flow field 4). In the embodiment shown in Figs. 1-4, each cathode gas flow plate has first and second gas flow channels (represented by the cathode gas flow field in Figs. 2 and 4). A series of switching devices 6, 7 and 8 are able to switch the connection between the first gas flow channel and the second gas flow channel within each gas flow plate from a series connection to a parallel connection, and from a parallel connection to a series connection depending on the desired result. By switching the connection between the first and second gas flow channels to a series connection (as shown in Figs. 1 and 2), the length of the flow path from the inlet to the outlet is maximized, which reduces flooding within the fuel cell that occurs during low power load conditions. By switching the connection between the first and second gas flow channels to a parallel connection (as shown in Figs. 3 and 4), the length of the flow path from the inlet to the outlet is shortened, which reduces the power requirements of fuel and air pumps during high power load conditions.

New independent claim 15 recites a fuel cell system which includes at least one cell having a cathode gas flow plate and an anode gas flow plate. The fuel cell system also includes a first gas flow channel and a second gas flow channel both provided in at least one of the cathode gas flow plate and the anode gas flow plate of the at least one cell. The fuel cell system further includes switching devices for switching a connection between the first and second gas flow channels within the at least one of the cathode gas flow plate and the anode gas flow plate from a parallel connection to a series connection, and from a series connection to a parallel connection.

McElroy discloses a fuel cell cascade flow system which, as shown in Fig. 1, includes a fuel cell stack 200 and a fuel cell stack 300 separated by a partition 110. Each fuel cell stack 200, 300 include a plurality of fuel cells 150, and each fuel cell includes an anode flow field plate 220 and a cathode flow field plate 210. The anode flow field plate 220 has channels 226 (as shown in Fig. 3) and the cathode flow field plate 210 has channels 216 (as shown in Fig. 4). Fuel

cell stack 200 has an inlet 280 and an outlet 290, and fuel cell stack 300 has ports 310, 320 and 330.

However, McElroy does not disclose switching devices for switching a connection between the first and second gas flow channels within the at least one of the cathode gas flow plate and the anode gas flow plate from a parallel connection to a series connection, and from a series connection to a parallel connection, as required by independent claim 15. Rather, McElroy discloses a series of valves 500, 510, 520 which switch the connection between separate stacks of fuel cells from a series connection to a parallel connection. McElroy discloses at column 6, lines 8-24, that during low power output conditions, the valves 500, 510, 520 are set such that gas flows through the fuel cell stack 200 and then enters fuel cell stack 300 after leaving the fuel cell stack 200 (*i.e.*, gas flows through fuel cell stacks 200, 300 in series). McElroy also discloses at column 6, lines 28-41, that during high power output conditions, the valves are set such that gas flows through fuel cell stack 200 and, at the same time, gas flows through fuel cell stack 300 from port 310 (*i.e.*, gas flows through fuel cell stacks 200, 300 in parallel). Therefore, McElroy does not disclose switching devices for switching a connection between first and second gas flow channels within the gas flow plate of a cell, because McElroy only discloses switching the connection between separate stacks of fuel cells.

Therefore, it is respectfully submitted that new independent claim 15, as well as claims 16-24 which depend therefrom, are clearly allowable over the prior art of record.

In view of the foregoing amendments and remarks, it is respectfully submitted that the present application is clearly in condition for allowance. An early notice to that effect is respectfully solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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September 14, 2006

Version with Markings to Show Changes Made

FUEL CELL

Background of the Invention

Field of the invention

[0001] The present invention relates to fuel cell.

Description of the Related Art

[0002] There has been the urgent demand of higher performance and durability for fuel cells, especially polymer electrolyte fuel cell (PEFC) which is expected as the future power source in the field of stationary or transportation use from the environmental point of ~~views~~view. However this demand has not been attained by the present time, because its technological problems were mainly derived from the essential technological problems described ~~bellow~~below.

[0003] The electric power is generated by feeding the anode gas of hydrogen or hydrogen containing gas into the anode gas flow field and the cathode gas of air o r oxygen containing gas into the cathode gas flow field respectively. The power is controlled by the amount of ~~the~~ both the gases, that is, the feeding rates into the gas flow fields have to be in proportion to the loading level needed for its consumption power. When the feeding rate i s increased, the gas pressure drop from inlet to outlet through the gas flow field is tremendously increased, since the gas flow plate has a long serpentine gas flow field. This means that the higher pressure drop increases the consumption of electricity for the cathode gas or fuel feed pump resulting in the low efficiency of the energy. Furthermore, this means that the time to reach the steady state of a certain gas feeding rate is far from the needed one for the response to the change of needed power resulting in the further low efficiency of the energy.

[0004] When the feeding rate is decreased, ~~the~~ water flooding occurs in the anode and cathode gas flow fields by the ~~remained~~ remaining water not to be expelled by the increase of the gas velocity through the gas flow field. The influence of water flooding is seriously appeared in

the cathode site, because of the production of water is produced at the cathode according the reaction (2).

Anode:	$H_2 \rightarrow 2H^+ + 2e$	(1)
Cathode:	$1/2O_2 + 2H^+ + 2e \rightarrow H_2O$	(2)
Total:	$H_2 + 1/2O_2 \rightarrow H_2O$	(3)

[0005] This water flooding has been considered as one of essential harmful failure mode for the performance of PEFC resulting in the drop of operation voltage and poor life performance. Therefore, the new technology to compensate both phenomena of water flooding at the low power load and high pressure drop at the high power load in the wide range is strongly demanded for the practical use of PEFC.

Brief Summary of the Invention

[0006] The present invention provides the high performance with no water flooding phenomenon at the low power load and low pressure drop in the gas flow field of the plate with no excess power needed for the auxiliary system of air or fuel feed pump at the high power load by using the novel function of a variable gas flow channel as described in more ~~details~~ detail later.

[0007] The fuel cell according to the invention has ~~the~~ thefollowing features; the fuel cell has the variable gas flow channel with the function of switching the connection between one gas flow channel and ~~the anther one~~another gas flow channel from series to parallel or from parallel to series by the operation of equipped switching device according to the needed power for fuel cell.

[0008] The effect of the function of the present invention remarkably improves the performance at the low power load with the low feed rates of the reaction gases of air and fuel with free of the water flooding problem in the gas flow field in the plate by the increase o f gas v elocity i n the gas flow field b y switching to the series connection of the channels to expel the ~~remained~~ remaining water. The further effect by the present invention remarkably reduces the high pressure drop appeared at the high power load operation in the case of the usage of the above-mentioned novel function of switching to parallel connection of the channels, namely, switching the gas flow channel from the long path to the short path with from the inlet to outlet for reaction gas. This function leads to save the consumption of energy needed for the auxiliary apparatuses of air and fuel feed pumps resulting in the high energy efficiency of PEFC. The PEFC according to the present invention is able to operate at the condition of wide range of power load with the no water flooding and no high pressure drop resulting in the high performance and high durability performance.

Brief Description of the ~~Drawing~~Drawings

[0009] Fig.1 shows the cross-sectional view of a schematic model with cathode gas flow direction for PEFC with a function of variable gas flow channel at the cathode side for low power load operation with series connection of gas flow channels according to the present invention.

[0010] Fig.2 shows the schematic gas flow direction of the gas flow plate of PEFC for the low power load operation with series connection of gas flow channels according to the present invention.

[0011] Fig.3 shows the cross-sectional view of a schematic model with cathode gas flow direction for PEFC with a function of variable gas flow channel at the cathode side for high power load operation with parallel connection of gas flow channels according to the present invention.

[0012] Fig.4 shows the schematic cathode gas flow direction of the gas flow plate of PEFC for the high power load operation with parallel connection of gas flow channels according to the present invention.

[0013] Fig.5A, B, C show the schematic cathode gas flow direction of the gas flow plate of PEFC with the function of three types of variable gas flow channels 4 series, 2 series – 2 parallels, and 4 parallels, respectively, according to the present invention.

[0014] Fig.6 shows the cross-sectional view of another schematic model with cathode gas flow direction for PEFC with a function of variable gas flow channel at the cathode side with series connection of gas flow channels for low power load operation according to the present invention.

[0015] Fig.7 shows the cross-sectional view of schematic model with cathode gas flow direction for PEFC with a function of variable gas flow channel at the cathode side with parallel connection of gas flow channels for high power load operation according to the present invention.

[0016] Fig.8 shows the comparison of the representative I -V characteristics for the PEFC with function of a variable gas flow channel at the cathode side according to the present invention with one of the existing PEFC.

[0017] Fig.9 shows the comparison of the representative pressure drop of cathode gas for the PEFC with function of a variable gas flow channel at the cathode side according to the present invention with one of the existing PEFC as the function of current density.

[0018] Fig.10 shows the cross-sectional view of a schematic model with cathode gas flow direction for the existing PEFC with a conventional gas flow channel.

[0019] Fig.11 shows the schematic cathode gas flow direction in the gas flow plate of PEFC for the existing gas flow channel.

[0020] Fig.12 shows the cross-sectional view of a schematic model with anode gas flow direction for PEFC with a function of variable gas flow channel at the anode side for low power load operation with series connection of gas flow channels according to the present invention.

[0021] Fig.13 shows the cross-sectional view of a schematic model with anode gas flow direction for PEFC with a function of variable gas flow channel at the anode side for high power load operation with parallel connection of gas flow channels according to the present invention.

[0022] Fig.14 shows the comparison of the representative I-V characteristics for the PEFC with function of variable gas flow channel at the anode side according to the present invention with one of the existing PEFC.

[0023] Fig.15 shows the comparison of the representative pressure drop of anode gas for the PEFC with function of variable gas flow channel at the anode side according to the. present invention with one of the existing PEFC as the function of current density.

Detailed Description of the Invention

[0024] The present invention is applied to the various types of fuel cells such as polymer electrolyte fuel ~~cell~~ cells (PEFC), phosphoric acid fuel ~~cell~~cells (PAFC), molten carbon fuel ~~cell~~cells (MCFC), alkaline fuel ~~cell~~cells (AFC), and solid oxide fuel ~~cell~~cells (SOFC). Especially, the present invention is effective in PEFC because of its relatively low operating temperature compared with ~~another type~~other types of fuel cells.

[0025] ~~Fuel~~ A fuel cell stack is designed with ~~the~~ several single cells in series. The fuel cell in this specification means both a stack and a single cell of a fuel cell. The PEFC described in this specification means a stack or a single cell of a PEFC. The single cell is mainly composed of the following serial constitution parts; an end plate, ~~/~~a gas flow plate~~/~~, a gas diffusion backing~~/~~, a membrane electrode assembly (MEA)~~/~~, a gas diffusion backing~~/~~, a gas flow plate~~/~~ and an end plate. The gas flow plates are made of graphite or metallic materials and have the serpentine gas flow channel field used for the feed of cathode gas or anode gas. The gas diffusion backing is generally used of carbon fiber or carbon cloth with hydrophobic ~~property~~properties. The MEA is composed of an anode catalyst layer~~/~~, a polymer electrolyte membrane~~/~~ and a cathode catalyst layer. In some cases, the gas flow p lates have the c oolant channel for water circulation.

[0026] A PEFC stack contains several gas flow plates which have a gas flow field. Therefore, the PEFC stack comprises the manifolds for the cathode gas and anode gas to distribute the gases into each gas flow field. Plural gas flow channels are comprised at cathode side or anode side in PEFC according to the present invention. The function of the variable gas flow channel is to switch the connection between one gas flow channel and another ~~one~~ gas flow channel from series to parallel or from parallel to series. Namely, this function of the variable gas flow channel according to the present invention i s able t o change the distance o f the p ath from the gas feed inlet to the gas outlet with simple constitution. For example, the s witch from series t o p arallel o f the connection with the function of the variable gas flow channel leads to a shorter path from the gas feed inlet to the gas outlet. This function leads to save consumption of energy needed for the auxiliary apparatuses such as air and fuel feed ~~p ump~~ pumps resulting i n the high energy efficiency of high power load for PEFC. 0 n the other h and, the s witch from p arallel t o s eries o f t he connection with the function of the variable gas flow channel leads to a longer path from the gas feed inlet to the gas outlet. This function leads to suppress the drop in the operation voltage of the PEFC caused ~~of~~ by the w ater flooding phenomena ~~appeared~~ appearing under the low power load condition. Especially, the function according to the present invention is

effective for the stack of fuel ~~cell~~cells, because flooded water at the gas flow field in the stack is hard to be removed by gas flow.

[0027] ~~A~~ The number of the gas flow ~~channel~~ channels according to the present invention is two or equal to or greater than three for the same gas in the single cell. In the case of two gas flow channels in the PEFC for example, the variable gas flow channel is able to switch the connection from ~~the~~ parallel t o s eries o r the reverse. The PEFC of this case is able to be compact because of simple constitution. In the case of four gas flow channels in the PEFC for example, the variable gas flow channel is able to switch the connection between three steps, 4 series, 2 series — 2 parallels, and 4 parallels. The PEFC of this case is able to operate sophisticatedly at ~~more wide~~a wider range of power load.

[0028] An air pump means an oxidant supplying source that contains an air blower, an air compressor, an air fan, an air cylinder and an oxygen cylinder for example. A fuel pump means a fuel supplying source that contains a hydrogen pump, and a fuel reformer. A switching device is used for PEFC according to present invention for the appearance of variable gas flow channel functions. For the concrete examples ~~as~~ of the switching device, there is a valve, a solenoid valve or a ball valve, and so on for the switching device. The switching device is preferred to be set in the part of a gas flow inlet, a gas flow outlet or gas flow path in order to control the gas flow. The switching device is able to be set on a part of the manifold connected to a gas flow inlet or a gas flow outlet. The automatic operation of the switching device is operated according to the magnitude of power load to control the gas flow rate, gas flow velocity or gas pressure.

[0029] The present invention provides the high efficiency for PEFC with the novel technology of the variable gas flow channel with the function of reduction of pressure drop ~~appeared~~ appearing in the high power load and no occurrence of water flooding at the low power load. The function of the variable gas flow channel according to the present invention is effective for each ~~of~~ anode side or cathode side. The PEFC, which has the function o f a variable gas flow

c harmel at the c athode side, i s effective because the water flooding is easy to occur by the water generating reaction. The PEFC, which has the function of a variable gas flow channel at the anode side, is to be effective because the variation of anode gas flow velocity is large by high gas utilization. Especially, the PEFC with the function at both anode and the cathode sides provides the superior performance. The present invention is described in more detailed concrete examples with the function at cathode side as a representative model.

[0030] The cross-sectional view of the schematic model with the gas flow direction for the PEFC comprising three single c ells ins eries with the function o f the variable gas flow channel according to the present invention is shown in Fig.l. The cathode gas of air is fed from its feed inlet 1 to the first cathode gas manifold 2 and distributed into the cathode gas flow field 4 fabricated on the gas flow plate 5 and finally to the cathode gas outlet 3 with switching device 6 through third cathode gas manifold 2. The second cathode gas manifold of the center is not used for gas distribution in this case. The switching devices 7 and 8 are closed in this case. The flow field geometry of the cathode gas flow field is not depicted 'for the clearness of gas direction. The anode gas flow field 9 and MEA 10 are also depicted in Fig.l. ~~Type~~ The of connection of the two gas flow channels is in series in this case. The preferable embodiment of invention the series connection type for variable gas flow channel according to the present is shown in Fig.2 with the same switching device operation as Fig.1 wherein the situation is proper for the-low power load condition to suppress the water flooding.

[0031] The cross-sectional view of the schematic model with gas flow direction for PEFC with the function of the variable gas flow channel according to the present invention is shown in Fig.3. This figure is the different situation obtained by the. other selection of operation of switching devices 6, 7, 8, wherein the cathode gas of air is fed from two cathode gas feed inlets 1 to two cathode gas manifolds 2 in the center after being distributed into two cathode gas flow fields 4 fabricated on the gas flow plate 5 from two directions, and finally to cathode gas outlet 3 through the manifold 2 of the center. The switching device 6 is only closed in this case.

The velocity of air through the gas flow fields is half of the case in Fig.1 with the slight change of the switching device operation. The effect of the preset invention is clearly recognized by the glance of the flow direction depicted in Fig.4.

[0032] The preferable embodiment of the invention with the parallel connection type for the variable gas flow channel according to the present is shown in Fig.4 with the same switching device operation as Fig.3 wherein the situation is proper for the low power load condition to suppress the pressure drop leading to the high energy efficiency with the low consumption of energy needed for the auxiliary apparatuses of air and fuel feed pumps. Furthermore, the present invention is able to provide the three steps of variable gas flow channel for the PEFC with four gas flow channels is responsible ~~to~~ for the wide range of power load. The representative gas flow direction of the gas flow field is only shown in Fig.5, because of the clear effect of this invention. Fig.5 A, Fig.5 B and Fig.5 C show the 4 series, 2 series – 2 parallels, and 4 parallels connection type, respectively, with the slight change of the operation of the switching device for the same configuration of then PEFC. The PEFC with three gas flow channels is also responsible ~~to~~ for the wide range of power load. For example, the P EFC i s e ffective for wide power 1 oad range operation as idling and operating condition.

[0033] In the case of from Fig. 1 to Fig. 5, the PEFC comprises a gas manifold, which is shared by a plurality of ~~said~~ the gas flow channels, for example, according to the present invention. This type of PEFC is able to be compact because of the number ~~of~~ gas ~~manifold~~ manifolds is small. Fig.6 shows another type of PEFC according to the present invention with the same function without a change of gas flow direction by switching of the connection in the gas flow field for low power load operation with series connection of the gas flow channels according to the present invention. T his type of PEFC is able to avoid the water flooding problem because gas flow direction can orient for the direction of gravity. The PEFC comprises a gas flow path, which connects the gas stream between the gas manifolds and ~~have~~ has the switching device. Fig.6 shows another type of PEFC with the same function without a change of

gas flow direction in the gas flow field by switching of the connection for high power load operation with parallel connection of gas flow channels shown in Fig. 7.

[0034] ~~The some~~Some examples according to the present invention are concretely described below.

[Example 1]

[0035] The MEA was prepared by the hot-pressing of a cathode catalyst layer and an anode catalyst layer on ~~the~~ both sides of polymer electrolyte membranes (Nafion 115) as reported in elsewhere (J. Soler et.al, Journal of the power sources, 118 (2003) 172-178, Proton Conducting Membrane Fuel Cells I, Edited by S. Gottesfeld, G. Halpert and A. Landgrebe, P115 published by Electrochemical Society, Inc.(1995)). Pt and Pt-Ru was used for catalyst metal of the cathode and anode, respectively. ~~The each~~Each catalyst loading level was 0.5 mg/cm2, ~~the~~ and surface area was 100cm2. The PEFC A was designed with the three single cells in series. The single cell was composed of the following series constitution parts; an end p late~~/~~, a gas flow p late~~/~~, a gas diffusion backing~~/~~, a membrane electrode assembly (MEA)~~/~~, a gas diffusion backing~~/~~ and an end plate. The gas flow plates were made of graphite with thickness of a 2 mm and had the serpentine gas flow channel with 1 mm groove width. The gas diffusion backing was used of carbon cloth of 0.2mm thick treated with PTEF dispersion solution for hydrophobic property. The end plates were used the titanium plates with Au plating. The construction of PEFC A was the same ~~one~~ as the PEFC depicted in Fig.1 with the function of the variable gas flow channel at the cathode side. The performance for this PEFC A was investigated at the operation temperature of 80°C under the condition of natural gas reformate (Hydrogen 80%, Carbon dioxide 20%, Carbon monoxide 1 Oppm) as the anode gas and air as the cathode gas. Utilization of the air was 40% for operation of each current density. ~~Gas~~ The gas flow rate of the reformate was constant of utilization 80% at 500 mA/cm2 for operation of each current density. ~~The both~~Both gases were humidified at the same temperature. The operation voltage and

pressure drop measured by the difference between inlet and outlet of cathode gas flow. The current- voltage and current-pressure drop characteristics are shown in Fig. ~~12~~ 8 and Fig. ~~13~~9. For reference, the existing PEFC B, was also prepared with the same process as the PEFC A without the variable gas flow channels. The PEFC A according to the present invention shows the superior performance in the current-voltage characteristics compared with the case of the existing PEFC B especially in the range of current density of 0 to 150 mA/cm2. This means that the PEFC A according to the present invention shows no occurrence of ~~the~~ water flooding leading to the voltage drop in the operation voltage. This fact was strongly supported by the observation of the relatively higher velocity of the flow gas at the low current density under 200 mA/cm2 easily to expel the remained water of cathode in this present invention case. In the high current density region, the PEFC A according to the present invention shows the superior performance on the point of the pressure drop compared with the case of the existing PEFC B. This means that the present invention provides the high energy efficiency by the saving of the energy needed for the auxiliary apparatuses of the air feed pump.

[Example 2]

[0036] The MEA was prepared by the hot-pressing of a cathode catalyst layer and an anode catalyst layer on ~~the~~ both sides of polymer electrolyte membranes (Nafion 115) as reported in elsewhere. Pt and Pt-Ru was used for catalyst metal of cathode and anode respectively. ~~The each~~Each catalyst loading level was 0.5 mgkm2, and the surface area was 100cm2. The PEFC C was designed with the three single cells in series. The single cell was composed of the following series constitution parts; an end plate~~/~~, a gas flow plate~~/~~, a gas diffusion backing~~/~~, a membrane electrode assembly (MEA)~~/~~, a gas diffusion backing~~/~~, a gas flow plate~~/~~ and an end plate. The gas flow plates were made of graphite with a thickness of 2 mm and had the serpentine gas flow channel with 1 mm groove width. The gas diffusion backing was used of carbon cloth of 0.2mm thick treated with PTFE dispersion solution for hydrophobic property. The end plates were used the titanium plates with Au plating. The construction of

PEFC C was the same as the one depicted in Fig.12 and Fig. 13 with the function of the variable gas flow channel at the anode side. Fig 12 shows the cross-sectional view of schematic model with anode gas flow direction for PEFC with a function of variable gas flow channel at anode side for low power load operation with series connection of gas flow channels according to the present invention. Fig.13 shows the cross-sectional view of schematic model with anode gas flow direction for PEFC with a function of variable gas flow channel at anode side for high power load operation with parallel c onnection o f gas flow channels according to the present invention. Therefore, the model contains two gas flow channels for anode gas. The anode gas of reformate is fed from its feed inlet 11 to the first anode gas manifold 12 and distributed into the anode gas flow field 9 fabricated on the gas flow plate 5 and finally to the anode gas outlet 13 with switching device 6 through third anode gas manifold 12. ~~Second~~ The second anode gas manifold of the center is not used for gas distribution in this case. Switching devices 7 and 8 are closed in this case. The flow field geometry of the anode gas flow field is not depicted for the clearness of gas direction. The anode gas flow field 9 and MEA 10 are also depicted in Fig.12. The performance for this PEFC C was investigated at the operation temperature of 80°C under the condition of natural gas reformate (Hydrogen 80%, Carbon dioxide 20%, Carbon monoxide 1 Oppm) as anode gas and air as cathode gas. ~~Gas~~ The flow rate of the air was constant of utilization 40% at 500 mA/cm2 for operation of each current density, Utilization of the reformate was 80% for operation of each current density. ~~The both~~Both gases were humidified at the same temperature. The operation voltage and pressure drop measured by the difference between inlet and outlet of anode gas flow. The current- v oltage and current-pressure drop characteristics are shown i n Fig. 14 and Fig. 15. For reference, the existing PEFC D was also prepared with the same process described in example 2 without variable gas flow channels. The PEFC C according to the present invention shows the superior performance in the current-voltage characteristics compared with the case of the existing PEFC D especially in the range of current density of 0 to 150 mA/cm^2. This means that the PEFC C according to the present invention shows no occurrence of ~~the~~ water flooding leading to the voltage drop in the operation voltage. This fact was strongly supported by the observation of relatively higher velocity of the flow gas under the

low current density under 200 mA/cm2 easily to expel the water of anode in this present invention -case. In the high current density region, the PEFC C according to the present invention shows the superior performance on the point of the pressure drop compared with the case of the existing PEFC D. This means that the present invention provides the high energy efficiency by the saving the energy needed for the auxiliary apparatuses of anode gas feed pump.

[0037] Needless to say, the PEFC with the function at both anode and cathode sides provides the superior performance.

ABSTRACT

A fuel cell ~~composed with a~~includes plural gas flow channels, a switching device, and a variable gas flow channel with the function of ~~to switch~~switching the connection between one gas flow c hannel and another ~~one~~ gas flow channel from series t o p arallel o r from parallel to series.